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AUTHORS
Nicholas M. Odhiambo

ARTICLE INFO
Nicholas M. Odhiambo (2010). Electricity consumption, labour force participation rate and economic growth in Kenya: an empirical investigation. Problems and Perspectives in Management, 8(1)

JOURNAL
"Problems and Perspectives in Management"

FOUNDER
LLC “Consulting Publishing Company “Business Perspectives”

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Nicholas M. Odhiambo (South Africa)

Electricity consumption, labour force participation rate and economic growth in Kenya: an empirical investigation

This study examines the dynamic causal relationship between electricity consumption and economic growth in Kenya during the period of 1972-2006. Unlike most of the previous works, the current study incorporates the labor force participation rate as an intermittent variable in the bivariate causality setting between electricity consumption and economic growth – thereby creating a simple trivariate causality model. Using cointegration and error-correction models, the study finds a distinct unidirectional causal flow from electricity consumption to economic growth in Kenya. In addition, the study finds that both economic growth and electricity consumption Granger-cause labor force participation in Kenya. The results apply irrespective of whether the causality is estimated in the short run or in the long run. The study, therefore, concludes that electricity consumption is a panacea for economic growth in Kenya and any energy conservation policies should be treated with extreme caution.

Keywords: Africa, Kenya, electricity consumption, labor force participation, economic growth.

JEL Classification: Q43, C32.

Introduction

The causal relationship between electricity consumption and economic growth has important implications, especially from a policy standpoint (see Asafu-Adjeaye, 2000; Ghosh, 2002; Paul and Bhattacharya, 2004; Narayan and Smyth, 2005; Narayan and Singh, 2007). A unidirectional causality running from GDP to electricity consumption, for example, may imply that a country is not entirely dependent on electricity for its economic growth, and that energy conservation policies may be implemented with little or no adverse effects on economic growth. However, a unidirectional causality running from electricity consumption to economic growth implies that economic growth is dependent on electricity consumption, and a decrease in electricity consumption will unambiguously restrain economic growth (see also Narayan and Singh, 2007, p. 1142). The finding of no causality in either direction, i.e. the so-called ‘neutrality hypothesis’, on the other hand, implies that energy conservation policies have no effect on economic growth (see Asafu-Adjeaye, 2000; Paul and Bhattacharya, 2004).

Although the causal relationship between electricity consumption and economic growth has attracted numerous empirical studies during the past three decades, the majority of the previous studies have concentrated mainly on Asia and Latin America, affording sub-Saharan African countries either very little or no coverage at all. Even where such studies have been undertaken, the empirical findings on the direction of causality between electricity consumption and economic growth have been largely inconclusive. Moreover, the majority of the previous studies are mainly based on a bivariate framework and may, therefore, suffer from the omission of variables bias. In other words, the introduction of a third variable affecting both electricity consumption and economic growth in the bivariate causality setting may not only alter the direction of causality between the two variables, but also the magnitude of the estimate. It is against this backdrop that current study attempts to examine the inter-temporal causal relationship between electricity consumption and economic growth in Kenya by incorporating the labor participation rate as a third explanatory variable in a bivariate setting – thereby, creating a simple trivariate causality model. The rest of the paper is structured as follows: Section 1 discusses energy policies in Kenya as well as the recent trends of electricity consumption in the country. Section 2 presents the literature review, while Section 3 deals with the empirical model specification, estimation technique and the empirical analysis of the regression results. The final section concludes the study.

1. An overview of energy sector in Kenya

The main sources of energy in Kenya include wood fuel, petroleum, hydropower and geothermal power. In addition, some renewable sources of energy such as solar and wind are currently being explored. Currently wood fuel provides about 68% of the total energy requirements, petroleum energy 20%, electricity 10%, while other alternative sources account for about 2%. A number of policies have been implemented since independence in order to address the energy needs in Kenya. The landmark policy paper that set the basis for development of the country was sessional paper No. 10 of 1965. The focus of this sessional paper was mainly on the Electric Power Act (CAP 314), which had been used to regulate the power sector for years. The second landmark paper was sessional paper No. 1 of 1986, which called for the establishment of the Department of Price and Monopoly Control (DPMC) within the Ministry of Finance (MOF) to monitor acts of...
restraint of trade and to enforce pricing in the various sectors including petroleum (UNEP, 2006: 16). The third significant policy move took place in 1997, when the Electric Power Act of 1997 was legislated to replace CAP314. The aim of this new legislation was to facilitate private sector participation in the provision of electricity. This led to the establishment of KENGEN in 1998. The Electric Power Act of 1997 also provided for rural electrification on a limited scale, using renewable energy technologies. Following the unprecedented power shortages in Kenya in 1999 and 2000, the country decided to formulate a comprehensive energy policy for the entire energy sector. The ultimate goal of this policy was to ensure an adequate, reliable, cost-effective and affordable energy supply for developmental needs, while at the same time paying attention to environmental protection and conservation.

The largest share of Kenya’s electricity supply comes from hydroelectric power – even though the country has great potential to produce electrical energy using geothermal power. Although for a long time Kenya had been importing electricity from Uganda, the recent major supply shortages experienced in Uganda caused by the expansion of the industrial sector and the lack of investment in the electricity generation, recently forced Kenya to rely largely on its own electricity supply. In fact, it is Kenya that currently exports electricity to Uganda (UNEP, 2006: 6). The electricity demand in Kenya, just as in other developing countries, exceeds the supply. The situation is particularly acute during droughts when dam reservoirs are low or when some of the hydroelectric generating plants are out of service. Kenya’s electricity consumption has been very erratic, especially during the last decade. For example, the electricity consumption per capita increased from 92.5 kWh in 1980 to 121.3 kWh in 1993. Between 1993 and 1996, the electricity consumption per capita increased significantly from 121.3 kWh in 1993 to 123.2 kWh in 1994, 125.1 kWh in 1995 and 128.1 kWh in 1996. Although the consumption decreased in 1997 to 126.2 kWh, it later increased to 127.4 kWh in 1998, before decreasing significantly to 118.0 kWh in 1999. In 2000, the electricity consumption per capita reached 105.9 kWh, the lowest consumption level since 1989. Between 2000 and 2002, the electricity consumption per capita increased steadily from 105.9 kWh to 120.3 kWh, respectively. Although the consumption somewhat decreased between 2002 and 2004, it later increased significantly between 2004 and 2007. Currently, the electricity consumption per capita is estimated at 154 kWh.

2. Literature review

The causal relationship between energy consumption and economic growth has been studied extensively, but with conflicting results. There are four views regarding the causal relationship between energy consumption and economic growth. The first view argues that energy consumption Granger-causes economic growth. The empirical work, which is consistent with this view includes studies such as Chang et al. (2001), Lee (2005), Narayan and Singh (2007), Yu and Choi (1985), Cheng (1997), Soytas and Sari (2003), Shiu and Lam (2004), Wolde-Rufael (2004), Wolde-Rufael (2006), Altinay and Karagol (2005), among others. The second view argues that it is economic growth that drives the energy consumption in many countries, and that as the economy grows the demand for energy from different sections of the economy increases. The empirical work, which is consistent with this view includes Kraft and Kraft (1978), Cheng (1999), Gosh (2002), Narayan and Smyth (2005) and Thoma (2004), among others. The third view, however, maintains that both electricity consumption and economic growth Granger-cause each other, i.e., that there is a bi-directional causality between electricity consumption and economic growth. This view has been widely supported by studies such as Masih and Masih (1997), Morimoto and Hope (2004), Paul and Bhattacharya (2004), Jumbe (2004), Soyta and Sari (2003), and Glasure and Lee (1997), among others.

Although the majority of previous studies have found a causal relationship between energy consumption and economic growth to exist, at least in one direction, the empirical findings of some previous studies have shown that no causality exists between energy consumption and economic growth. In other words, these studies maintain that energy consumption and economic growth are neutral with respect to each other. This finding has been supported by Akarca and Long (1980) for the case of the USA, Yu and Hwang (1984) for the case of the USA, Cheng (1995) for the case of the USA, and Cheng (1997) for the case of Mexico and Venezuela, among others. Table 1 shows the empirical findings of the causality between energy consumption and economic growth drawn from some previous studies.

<table>
<thead>
<tr>
<th>Year</th>
<th>Electricity Consumption per Capita (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>105.9</td>
</tr>
<tr>
<td>2001</td>
<td>120.3</td>
</tr>
<tr>
<td>2002</td>
<td>127.4</td>
</tr>
<tr>
<td>2003</td>
<td>118.0</td>
</tr>
<tr>
<td>2004</td>
<td>120.3</td>
</tr>
<tr>
<td>2005</td>
<td>127.4</td>
</tr>
<tr>
<td>2006</td>
<td>118.0</td>
</tr>
<tr>
<td>2007</td>
<td>154.0</td>
</tr>
</tbody>
</table>

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Table 1. Selected empirical findings on the causality between energy consumption and economic growth

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Region/Country</th>
<th>Direction of causality</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A: Studies in favor of a unidirectional causality from energy consumption to economic growth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yu and Choi (1985)</td>
<td>USA, UK, Poland, Korea, Philippines</td>
<td>Energy consumption → GNP in Korea and Philippines</td>
</tr>
<tr>
<td>Mash and Mash (1996)</td>
<td>India, Pakistan, Malaysia, Singapore, Indonesia, Philippines</td>
<td>Energy consumption → Real income in India</td>
</tr>
<tr>
<td>Cheng (1997)</td>
<td>Brazil, Mexico and Venezuela</td>
<td>Energy consumption → GDP in Brazil</td>
</tr>
<tr>
<td>Yang (2000)</td>
<td>Taiwan</td>
<td>Electricity consumption → Real GDP</td>
</tr>
<tr>
<td>Asafu-Adjaye (2000)</td>
<td>Asian developing countries</td>
<td>Energy consumption → Income in India and Indonesia</td>
</tr>
<tr>
<td>Chang et al. (2001)</td>
<td>Taiwan</td>
<td>Energy consumption → Output</td>
</tr>
<tr>
<td>Soytas and Sari (2003)</td>
<td>G-7 countries and emerging markets</td>
<td>Energy consumption → GDP in Turkey, France, Germany and Japan</td>
</tr>
<tr>
<td>Shiu and Lam (2004)</td>
<td>China</td>
<td>Electricity consumption → Real GDP</td>
</tr>
<tr>
<td>Wolde-Rufael (2004)</td>
<td>Shanghai</td>
<td>Energy consumption → Real GDP</td>
</tr>
<tr>
<td>Lee (2005)</td>
<td>Developing countries</td>
<td>Energy consumption → GDP</td>
</tr>
<tr>
<td>Altinay and Karagol (2005)</td>
<td>Turkey</td>
<td>Electricity consumption → Economic growth</td>
</tr>
<tr>
<td>Wolde-Rufael (2006)</td>
<td>17 African countries</td>
<td>Electricity consumption → GDP in Benin, Democratic Republic of Congo and Tunisia</td>
</tr>
<tr>
<td>Narayan and Singh (2007)</td>
<td>Fiji Islands</td>
<td>Electricity consumption → GDP</td>
</tr>
<tr>
<td>Odhiambo (2009a)</td>
<td>Tanzania</td>
<td>Energy consumption → Economic growth</td>
</tr>
<tr>
<td><strong>B: Studies in favor of a unidirectional causality from economic growth to energy consumption</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kraft and Kraft (1978)</td>
<td>USA</td>
<td>GNP → Energy consumption</td>
</tr>
<tr>
<td>Abosedra and Baghestani (1989)</td>
<td>USA</td>
<td>GNP → Energy consumption</td>
</tr>
<tr>
<td>Cheng and Lai (1997)</td>
<td>Taiwan</td>
<td>GDP → Energy consumption</td>
</tr>
<tr>
<td>Mash and Mash (1996)</td>
<td>India, Pakistan, Malaysia, Singapore, Indonesia, Philippines</td>
<td>Real income → Energy consumption in Indonesia</td>
</tr>
<tr>
<td>Cheng (1999)</td>
<td>India</td>
<td>GDP → Energy consumption</td>
</tr>
<tr>
<td>Gosh (2002)</td>
<td>India</td>
<td>Economic growth → Electricity consumption</td>
</tr>
<tr>
<td>Soytas and Sari (2003)</td>
<td>G-7 countries and emerging markets</td>
<td>GDP → Energy consumption in Italy and Korea</td>
</tr>
<tr>
<td>Narayan and Smyth (2005)</td>
<td>Australia</td>
<td>Real income → Electricity consumption</td>
</tr>
<tr>
<td>Yoo (2006)</td>
<td>4 ASEAN countries</td>
<td>Economic growth → Electricity consumption in Indonesia and Thailand</td>
</tr>
<tr>
<td>Mozumder and Marathe (2007)</td>
<td>Bangladesh</td>
<td>GDP → Electricity consumption</td>
</tr>
<tr>
<td><strong>C: Studies in favor of a bi-directional causality between energy consumption and economic growth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mash and Mash (1996)</td>
<td>India, Pakistan, Malaysia, Singapore, Indonesia, Philippines</td>
<td>Energy consumption ↔ Real income in Pakistan</td>
</tr>
<tr>
<td>Mash and Mash (1997)</td>
<td>2 NICs: Korea and Taiwan</td>
<td>Energy consumption ↔ Real income</td>
</tr>
<tr>
<td>Glasure and Lee (1997)</td>
<td>South Korea and Singapore</td>
<td>Energy consumption ↔ GDP</td>
</tr>
<tr>
<td>Soytas and Sari (2003)</td>
<td>G-7 countries and emerging markets</td>
<td>Energy consumption ↔ GDP in Argentina</td>
</tr>
<tr>
<td>Paul and Bhattacharya (2004)</td>
<td>India</td>
<td>Energy consumption ↔ Economic growth</td>
</tr>
<tr>
<td>Yoo (2006)</td>
<td>4 ASEAN countries</td>
<td>Electricity consumption ↔ Economic growth in Malaysia and Singapore</td>
</tr>
<tr>
<td>Odhiambo (2009b)</td>
<td>South Africa</td>
<td>Electricity consumption ↔ Economic growth</td>
</tr>
<tr>
<td><strong>D: Studies in favor of neutrality between energy consumption and economic growth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Akarca and Long (1980)</td>
<td>USA</td>
<td>Energy consumption [0] GNP</td>
</tr>
<tr>
<td>Yu and Hwang (1984)</td>
<td>USA</td>
<td>Energy consumption [0] GNP</td>
</tr>
<tr>
<td>Yu and Choi (1985)</td>
<td>USA, UK, Poland, Korea, Philippines</td>
<td>Energy consumption [0] GNP in USA, UK and Poland</td>
</tr>
<tr>
<td>Cheng (1995)</td>
<td>USA</td>
<td>Energy consumption [0] GNP</td>
</tr>
</tbody>
</table>
Table 1 (cont.). Selected empirical findings on the causality between energy consumption and economic growth

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Region/Country</th>
<th>Direction of causality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Masih and Masih</td>
<td>India, Pakistan, Malaysia, Singapore, Indonesia, Philippines</td>
<td>Energy consumption [0] Income in Malaysia, Singapore, Philippines</td>
</tr>
<tr>
<td>Cheng</td>
<td>Brazil, Mexico and Venezuela</td>
<td>Energy consumption [0] Economic growth in Mexico and Venezuela</td>
</tr>
<tr>
<td>Wolde-Rufael</td>
<td>17 African countries</td>
<td>Electricity consumption [0] Economic growth in Algeria, Congo (Rep), Kenya, South Africa and Sudan</td>
</tr>
</tbody>
</table>

Notes: →; ↔ and [0] denote unidirectional causality, bidirectional causality and neutrality (no causality), respectively.

3. Estimation techniques and empirical analysis

3.1. Empirical model specification. In this section, a dynamic Granger causality test is used to examine the direction of causality between electricity consumption and economic growth in Kenya. The Granger causality method is chosen in this paper over other alternative techniques because of its favorable response to both large and small samples (see Odhiambo, 2008). Unfortunately, causality studies based on a bivariate framework have been found to be very unreliable, as the introduction of a third important variable can change both the inference and the magnitude of the estimates (see also Cheng, 1997). To overcome these problems and perspectives in management, Volume 8, Issue 1, 2010

In addition to indicating the direction of causality amongst variables, the error-correction mechanism also enables us to distinguish between short-run and long-run Granger causality. The F-test and the explanatory variables indicate the “short-run” causal effects, whereas the “long-run” causal relationship is implied through the significance of the t-test of the lagged error-correction term. Based on the equations (1)-(3), the following causal relationships can be derived between electricity consumption, labor force participation and economic growth.

All the data used in this study were obtained from the Global Development Indicators CD-ROM, 2007.

Table 2. Causal flow between electricity consumption, labor force participation and economic growth

<table>
<thead>
<tr>
<th>Causal flow</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Electricity consumption (EC) → Economic growth (y/N)</td>
<td>$\lambda_0 \neq 0; \lambda_4 \neq 0$</td>
</tr>
<tr>
<td>(2) Economic growth (y/N) → Electricity consumption (EC)</td>
<td>$\phi_{1i} \neq 0; \phi_4 \neq 0$</td>
</tr>
<tr>
<td>(3) Labor force participation (LABF) → Economic growth (y/N)</td>
<td>$\delta_{1i} \neq 0; \delta_4 \neq 0$</td>
</tr>
</tbody>
</table>

3.2. Empirical analysis. 3.2.1. Stationarity test. The results of the stationarity tests at levels (not presented here) show that all the variables are non-stationary at levels. Having found that the variables are not stationary at levels, the next step is to difference the variables once in order to perform stationarity tests on differenced variables. The results of the stationarity tests on differenced variables – based on the Phillips-Perron, DF-GLS and Ng-Perron tests – are presented in Tables 3 and 4.

\[ \Delta y / N_t = \lambda_0 + \sum_{i=1}^{m} \lambda_{1i} \Delta y / N_{t-i} + \sum_{i=1}^{n} \lambda_{2i} \Delta EC_{t-i} + \sum_{i=1}^{n} \lambda_{3i} \Delta LABF_{t-i} + \lambda_4 ECM_{t-1} + \mu_t \]  

\[ \Delta EC_t = \phi_0 + \sum_{i=1}^{m} \phi_{1i} \Delta y / N_{t-i} + \sum_{i=1}^{n} \phi_{2i} \Delta EC_{t-i} + \sum_{i=1}^{n} \phi_{3i} \Delta LABF_{t-i} + \phi_4 ECM_{t-1} + \epsilon_t \]  

\[ \Delta LABF_t = \delta_0 + \sum_{i=1}^{m} \delta_{1i} \Delta y / N_{t-i} + \sum_{i=1}^{n} \delta_{2i} \Delta EC_{t-i} + \sum_{i=1}^{n} \delta_{3i} \Delta LABF_{t-i} + \delta_4 ECM_{t-1} + \nu_t \]  

1 See also Narayan and Smyth (2005).
The results reported in Tables 3 and 4 show that after differencing the variables once, all the variables were confirmed to be stationary. The DF-GLS and Phillips-Perron tests applied to the first difference of the data series reject the null hypothesis of non-stationarity for all the variables used in this study. It is, therefore, worth concluding that all the variables used in this study are integrated of order one.

### 3.2.2. Cointegration test

Having confirmed that all variables included in the causality test are integrated of order one, the next step is to test for the existence of a cointegration relationship between electricity consumption (EC), labor force participation (LABF) and economic growth (y/N). For this purpose, the study uses the Johansen-Juselius (maximum likelihood) cointegration test procedure. The results of the Johansen-Juselius cointegration test are presented in Table 5.

<table>
<thead>
<tr>
<th>Null</th>
<th>Alternative</th>
<th>Statistics</th>
<th>95% Critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r = 0</td>
<td>r ≥ 1</td>
<td>38.72</td>
<td>29.7</td>
</tr>
<tr>
<td>r ≤ 1</td>
<td>r ≥ 2</td>
<td>8.64</td>
<td>15.4</td>
</tr>
<tr>
<td>r ≤ 2</td>
<td>r = 3</td>
<td>0.025</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Notes: 1) r stands for the number of cointegrating vectors. 2) The lag structure of VAR is determined by the highest values of the Akaike information criterion and Schwartz Bayesian Criterion.

The results of the Johansen-Juselius cointegration test reported in Table 5 indicate the existence of a stable long-run relationship between electricity consumption (EC), the labor participation rate (LLABF) and economic growth (y/N). Both the trace test and the maximum eigenvalue statistics reject the null hypothesis of no cointegration. Specifically, the results show that there is a unique cointegrating vector between electricity consumption, labor force participation and economic growth.

### 3.2.3. Analysis of causality test based on error correction model

The results of the general (over-parameterized) causality tests between financial development, economic growth and poverty (not presented here) are difficult to interpret and many variables are not significant as expected. The electricity consumption (EC), the labor participation (LABF) and economic growth (y/N) equations are, therefore, reduced until the preferred models are obtained. A summary of the results of the preferred models of the causality test between EC, LABF and y/N are displayed in Table 6.

<table>
<thead>
<tr>
<th>Variables in equation</th>
<th>ΔLy/N</th>
<th>ΔLEC</th>
<th>ΔLLABF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.0075(1.383)</td>
<td>0.0195(1.314)</td>
<td>0.0029(-1.831)</td>
</tr>
<tr>
<td>ΔLy/N</td>
<td>-</td>
<td>1.1667(1.803)**</td>
<td>-</td>
</tr>
<tr>
<td>ΔLy/N-1</td>
<td>0.5010(3.718)**</td>
<td>-0.6796(-1.220)</td>
<td>0.0529(1.225)</td>
</tr>
<tr>
<td>ΔLy/N-2</td>
<td>0.3011(1.654)</td>
<td>-0.6534(-1.099)</td>
<td>0.0389(0.889)</td>
</tr>
<tr>
<td>ΔLy/N-3</td>
<td>-</td>
<td>-0.1547(-0.271)</td>
<td>-</td>
</tr>
<tr>
<td>ΔLy/N-5</td>
<td>-</td>
<td>-</td>
<td>0.1374(2.776)**</td>
</tr>
</tbody>
</table>

Notes: 1) The truncation lag is based on Newey and West (1987) bandwidth. 2) *** denotes statistical significance at the 1% level.
Table 6 (cont.). Causality test between DLy/N, DLEC and DLLABF

<table>
<thead>
<tr>
<th>Variables in equation</th>
<th>△Ly/N</th>
<th>△LEC</th>
<th>△LLABF</th>
</tr>
</thead>
<tbody>
<tr>
<td>△LEC</td>
<td>0.1491(2.383)**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>△LEC-2</td>
<td>-0.0389(-0.545)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>△LEC-4</td>
<td>-0.0187(-0.272)</td>
<td>-0.1533(-0.712)</td>
<td>0.0346(2.118)**</td>
</tr>
<tr>
<td>△LEC-5</td>
<td>-</td>
<td>-</td>
<td>0.0218(1.318)</td>
</tr>
<tr>
<td>△LLABF</td>
<td>-1.0867(-1.617)</td>
<td>0.5227(0.213)</td>
<td>-</td>
</tr>
<tr>
<td>△LLABF-1</td>
<td>-1.1303(-1.508)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>△LLABF-2</td>
<td>0.1877(0.297)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>△LLABF-3</td>
<td>-</td>
<td>2.3812(0.976)</td>
<td>0.5869(2.533)**</td>
</tr>
<tr>
<td>△LLABF-4</td>
<td>-</td>
<td>-1.8585(-1.121)</td>
<td>-</td>
</tr>
<tr>
<td>△LLABF-5</td>
<td>-</td>
<td>-1.6470(-1.166)</td>
<td>0.2851(2.640)***</td>
</tr>
<tr>
<td>ECM-1</td>
<td>-0.5290(-3.895)***</td>
<td>0.8705(1.582)</td>
<td>-0.1061(-2.412)**</td>
</tr>
<tr>
<td>F-Test</td>
<td>5.5243 [0.0009]</td>
<td>1.1311 [0.3929]</td>
<td>3.8536 [0.0064]</td>
</tr>
<tr>
<td>R²</td>
<td>0.7235</td>
<td>0.3859</td>
<td>0.6419</td>
</tr>
<tr>
<td>DW</td>
<td>2.08</td>
<td>2.03</td>
<td>1.68</td>
</tr>
<tr>
<td>AR</td>
<td>0.3940398 [0.6804]</td>
<td>0.74015[0.4927]</td>
<td>0.43007 [0.6573]</td>
</tr>
<tr>
<td>ARCH</td>
<td>0.0018413 [0.9663]</td>
<td>2.81410[0.1129]</td>
<td>0.00317 [0.9558]</td>
</tr>
<tr>
<td>RESET</td>
<td>0.0539840[0.8189]</td>
<td>0.85943[0.3669]</td>
<td>1.81390 [0.1948]</td>
</tr>
</tbody>
</table>

Notes: 1) *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively. 2) The numbers in parentheses represent t-statistics.

The empirical results reported in Table 6 show that there is a distinct unidirectional causal flow from electricity consumption to economic growth, both in the short run and in the long run. The long-run causality from electricity consumption to economic growth is supported by the coefficient of the lagged error-correction term in the economic growth function, which is negative and statistically significant, as expected. The short-run causality from electricity consumption to economic growth is, however, supported by the F-test and the coefficient of the electricity consumption variable in the economic growth function, which are both statistically significant. The reverse causality from economic growth to electricity consumption, however, is rejected by the lagged error-correction term and the F-statistic in the electricity function, which are both statistically insignificant. The results also show that both economic growth and electricity consumption Granger-cause labor force participation in Kenya. The unidirectional causality from economic growth to labor force participation is supported by the error-correction term, the F-statistic and the coefficient of the lagged economic growth variable in the labor force participation function, which are all statistically significant. Likewise, the unidirectional causality from electricity to labor participation is supported by the lagged error-correction term, the F-statistic and the coefficient of the lagged electricity variable in the labor force participation function, which are all statistically significant, as expected. The results apply irrespective of whether the causality is estimated in the short run or in the long run. A summary of the causality test between the three variables is presented in Table 7.

Table 7. Summary of causality tests

<table>
<thead>
<tr>
<th>Variables</th>
<th>Causality</th>
<th>General conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>△Ly/N (dependent variable), △LEC and △LLABF</td>
<td>- There is a distinct unidirectional causal flow from electricity consumption to economic growth.</td>
<td>- Electricity consumption Granger-causes economic growth.</td>
</tr>
<tr>
<td>△LEC (dependent variable), △Ly/N and △LLABF</td>
<td>- There is no causal flow from either electricity consumption or labor participation to electricity consumption.</td>
<td>- Neither economic growth nor labor force participation Granger-causes electricity consumption.</td>
</tr>
<tr>
<td>△LLABF (dependent variable), △Ly/N and △LEC</td>
<td>- There is a unidirectional causal flow from both economic growth and electricity consumption to labor force participation.</td>
<td>- Both electricity consumption and economic growth Granger-cause labor force participation.</td>
</tr>
</tbody>
</table>

Conclusion

This study attempts to examine the causal relationship between electricity consumption and economic growth in Kenya. The majority of the previous studies on this subject are mainly based on a bivariate causality framework and may, therefore, suffer from the omission of variables bias. In other words, the introduction of a third variable affecting both electricity consumption and economic growth in the bivariate setting may not only alter the direction of...
causality between the two variables, but also the magnitude of the estimate. Given this limitation, the current study incorporates the labor force participation rate as an intermittent variable in a bivariate model between electricity consumption and economic growth – thereby creating a simple trivariate causality framework. Using cointegration and error-correction models, the study finds a distinct unidirectional causal flow from electricity consumption to economic growth. The results also show that both economic growth and electricity consumption Granger-cause labor force participation in Kenya. The results apply irrespective of whether the causality is estimated in the short run or in the long run. The study, therefore, concludes that electricity consumption is a panacea for long-run economic growth in Kenya and energy conservation policies should be treated with extreme caution.

References